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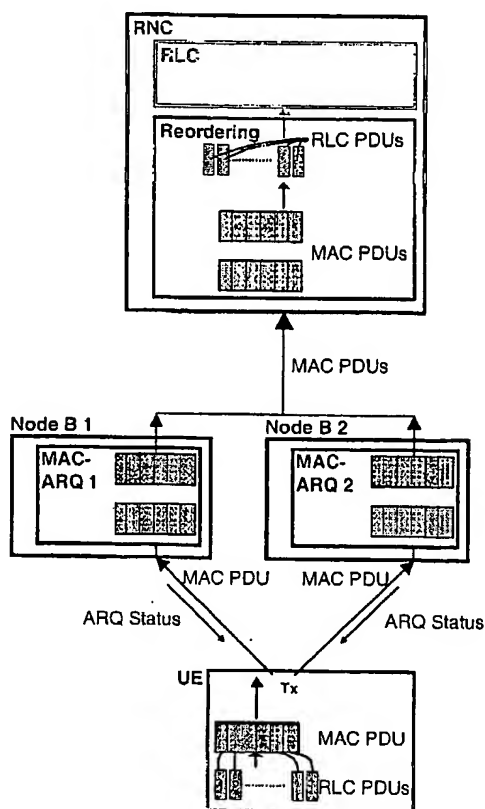
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(54) Title: **METHOD AND SYSTEM OF RETRANSMISSION**

(57) Abstract: The present invention relates to retransmissions in a communications system. A method and system of reducing uplink retransmission delay of a radio communications system by introducing an uplink MAC ARQ layer of Node B is disclosed. Further, a MAC PDU data indicator for soft combining control in Node B and RLC PDU reordering is introduced.



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Method and system of retransmission**TECHNICAL FIELD OF THE INVENTION**

The present invention relates to retransmissions in a communications system, and more especially it relates to a
5 cellular mobile radio system, particularly to a Universal Mobile Telecommunications System, UMTS or WCDMA system.

BACKGROUND AND DESCRIPTION OF RELATED ART

Retransmission of data to or from a mobile station, MS, or user equipment, UE, is previously known. It is also known
10 to use medium access control and radio link control layers of a UMTS protocol structure in acknowledged mode for dedicated channels.

In acknowledged mode, retransmissions are undertaken in case of detected transmission errors not recovered by forward error control. This is also called automatic repeat
15 request, ARQ. With ARQ, retransmissions can be undertaken unless a transmitted message is (positively) acknowledged. Retransmissions could also be initiated at explicit negative acknowledgments of transmitted messages. Generally
20 there are time limits for the respective positive and negative acknowledgements to be considered.

Within this patent application, a radio network controller, RNC, is understood as a network element including a radio resource controller. Node B is a logical node responsible
25 for radio transmission/reception in one or more cells to/from a User Equipment. A base station, BS, is a physical entity representing Node B.

Medium access control, MAC, and radio link control, RLC, is used within radio communications systems like General Packet Radio Services, GPRS, and UMTS.

5 U.S. Patent US5570367 discloses a wireless communications system arranged to transmit acknowledgement and request for retransmission messages. Data received in a microcell from an end user device is forwarded to a cell site. Data received by the cell site is transmitted to a cellular switch. A base station sends a poll message to the end
10 user device, inquiring for the status of unacknowledged messages previously transmitted from the base station.

Also, a base station transmitter window is defined. A lower end pointer identifies a lowest numbered packet transmitted to and acknowledged by the base station. The
15 upper end pointer identifies the highest numbered packet transmitted by the base station. Consequently, the window represents packets transmitted by the base station and unacknowledged by the end user device.

International Patent Application WO02096044 reveals a
20 method and system of reducing or eliminating transmissions over a scarce communication link resource in a communications system by establishing an image of downlink transmissions status.

International Patent Application PCT/SE02/02186 includes a
25 method and system for in-sequence delivery of RLC PDUs, transmitted in downlink direction, to a user equipment at handover.

3rd Generation Partnership Project (3GPP): Technical Specification Group Radio Access Network, Physical Layer Procedures, 3G TS 25.301 v3.6.0, France, September 2000, speci-
30

fies in chapter 5 Radio Interface Protocol Architecture of a UMTS system. There are three protocol layers:

- physical layer, layer 1 or L1,
- data link layer, layer 2 or L2, and
- 5 - network layer, layer 3 or L3.

Layer 2, L2, and layer 3, L3 are divided into Control and User Planes. Layer 2 consists of two sub-layers, RLC and MAC, for the Control Plane and four sub-layers, BMC, PDCP, RLC and MAC, for the User Plane. The acronyms BMC, PDCP,
10 RLC and MAC denote Broadcast/Multicast Control, Packet Data Convergence Protocol, Radio Link Control and Medium Access Control respectively.

Figure 1 illustrates a simplified UMTS layers 1 and 2 protocol structure for a Uu Stratum, UuS, or Radio Stratum,
15 between a user equipment UE and a Universal Terrestrial Radio Access Network, UTRAN.

Radio Access Bearers, RABs, make available radio resources (and services) to user applications. For each mobile station there may be one or several RABs. Data flows (in the
20 form of segments) from the RABs are passed to respective Radio Link Control, RLC, entities which amongst other tasks buffer the received data segments. There is one RLC entity for each RAB. In the RLC layer, RABs are mapped onto respective logical channels. A Medium Access Control, MAC,
25 entity receives data transmitted in the logical channels and further maps logical channels onto a set of transport channels. In accordance with subsection 5.3.1.2 of the 3GPP technical specification MAC should support service multiplexing e.g. for RLC services to be mapped on the same
30 transport channel. In this case identification of multi-

plexing is contained in the MAC protocol control information.

Transport channels are finally mapped to a single physical channel which has a total bandwidth allocated to it by the network. In frequency division duplex mode, a physical channel is defined by code, frequency and, in the uplink, relative phase (I/Q). In time division duplex mode a physical channel is defined by code, frequency, and time-slot. The DSCH (Downlink Shared Channel), e.g., is mapped onto one or several physical channels such that a specified part of the downlink resources is employed. As further described in subsection 5.2.2 of the 3GPP technical specification the L1 layer is responsible for error detection on transport channels and indication to higher layer, FEC encoding/decoding and interleaving/deinterleaving of transport channels..

PDPC provides mapping between Network PDUs (Protocol Data Units) of a network protocol, e.g. the Internet protocol, to an RLC entity. PDPC compresses and decompresses redundant Network PDU control information (header compression and decompression).

For transmissions on point-to-multipoint logical channels, BMC stores at UTRAN-side Broadcast Messages received from an RNC, calculates the required transmission rate and requests for the appropriate channel resources. It receives scheduling information from the RNC, and generates schedule messages. For transmission the messages are mapped on a point-to-multipoint logical channel. At the UE side, BMC evaluates the schedule messages and deliver Broadcast Messages to upper layer in the UE.

3G TS 25.301 also describes protocol termination, i.e. in which node of the UTRAN the radio interface protocols are

terminated, or equivalently, where within UTRAN the respective protocol services are accessible.

3rd Generation Partnership Project (3GPP): *Technical Specification Group Radio Access Network, Physical Layer Procedures*, 3G TS 25.322 v3.5.0, France, December 2000, specifies the RLC protocol. The RLC layer provides three services to the higher layers:

- transparent data transfer service,
- unacknowledged data transfer service, and
- 10 - acknowledged data transfer service.

In subsection 4.2.1.3 an acknowledged mode entity, AM-entity, is described (see figure 4.4 of the 3GPP Technical Specification). In acknowledged mode automatic repeat request, ARQ, is used. The RLC sub-layer provides ARQ functionality closely coupled with the radio transmission technique used. The 3GPP technical specification also reveals various triggers for a status report to be transmitted. The receiver shall always send a status report, if it receives a polling request. There are also three status report triggers, which can be configured

1. Missing PU(s) Detected,
2. Timer Initiated Status Report, and
3. Estimated PDU Counter.

For trigger 1, the receiver shall trigger transmission of a status report to the sender if a payload unit, PU, is detected to be missing. (One PU is included in one RLC PDU.) With trigger 2, a receiver triggers transmission of a status report periodically according to a timer. Finally, trigger 3 relates in short to a timer corresponding to an estimated number of received PUs before the requested PUs

are received. The 3GPP Technical Specification specifies a status PDU used to report the status between two RLC AM ('Acknowledged Mode') entities.

3rd Generation Partnership Project (3GPP): *Technical Specification Group Radio Access Network, High Speed Downlink Packet Access (HSDPA), Overall Description, 3G TS 25.308 v5.3.0, France, December 2002*, describes the overall support of High Speed Downlink Packet Access in UTRA. Figures 5.1-1 and 5.1-2 illustrate protocol architecture of HS-DSCH. Chapter 6 specifies HS-DSCH MAC architecture for the downlink.

3rd Generation Partnership Project (3GPP): *Technical Specification Group Radio Access Network, UTRAN Overall Description, 3G TS 25.401 v4.5.0, France, September 2002*, describes the overall architecture of UTRAN, including internal interfaces and assumptions on radio and Iu interfaces. Section 11.2.5 presents the DSCH Transport channel. DSCH scheduling is performed by MAC-c/sh in the CRNC.

3rd Generation Partnership Project (3GPP): *Technical Specification Group Radio Access Network, Physical layer aspects of UTRA High Speed Downlink Packet Access, 3G TS 25.848 v4.0.0, France, March 2001*, describes, among other things, physical layer aspect of the techniques behind the concept of high-speed downlink packet access (HSDPA). Section 6.3.1 presents a complexity analysis of a dual channel stop-and-wait protocol for downlink hybrid ARQ.

3rd Generation Partnership Project (3GPP): *Technical Specification Group Radio Access Network, Physical layer aspects of UTRA High Speed Downlink Packet Access, 3G TS 25.950 v4.0.0, France, March 2001*, describes several techniques for facilitating high-speed downlink packet access. Chap-

ter 8 describes various properties of stop-and-wait hybrid ARQ.

None of the cited documents above discloses a method and system of reducing uplink retransmission delay of a radio communications system by introducing an uplink MAC ARQ layer of Node B. Further, none of the cited documents mentions a MAC PDU data indicator for soft combining control in Node B.

SUMMARY OF THE INVENTION

10 Cited prior art references describe retransmissions between a UE and an RNC. According to preferred embodiments of the invention, transmissions and retransmissions are partially terminated in Node B, rendering soft combining of subsequent transmissions possible. Corresponding acknowledgements (positive or negative), if any, are terminated in UE.

Current WCDMA uplink connections has a latency in an approximate range of 100-150 ms. This latency is of such an amount that for some humans it is considered annoying, e.g., when using interactive services over the connection.

20 Further, present WCDMA releases provide wide area coverage for uplink data rates of 384 kbps. Applications proposed or recently presented require high peak rates in the uplink.

Consequently, it is an object to reduce transmission delay and latency over a scarce resource such as a radio interface.

A further object is to generate ARQ status reports in Node B and to render possible soft combining of subsequent (re-)transmissions.

It is also an object to segment RLC PDUs into MAC PDUs suitable for transmission in one transmission time interval, that may be shorter than allowed transmission time intervals of present WCDMA releases.

- 5 Finally, it is an object to introduce a reordering entity of RNC, handling RLC-PDUs received out of order, for improved out-of-order handling at RNC.

These objects are met by the invention, which is particularly well suited for a high-speed uplink packet access
10 channel of an evolved universal mobile telecommunications system.

Preferred embodiments of the invention, by way of examples, are described with reference to the accompanying drawings below.

15 BRIEF DESCRIPTION OF THE DRAWINGS

Figure 1 displays a layered protocol structure, according to prior art, in a radio communications system.

Figure 2 displays a layered protocol structure, according to the invention, in a radio communication system.

- 20 Figure 3 shows communication, according to the invention, between a UE and a base station involved in a connection between an RNC and the UE.

Figure 4 schematically illustrates MAC and RLC protocol layers, according to the invention, in a multilayer proto-
25 col structure.

Figure 5 gives an overview of the uplink protocol structure according to a preferred embodiment of the invention.

Figure 6 shows a MAC PDU according to the preferred embodiment of the invention.

Figure 7 illustrates transmission of data and associated control fields on separate channels, according to the invention.

Figure 8 illustrates N time multiplexed channels for N channel stop-and-wait according to the preferred embodiment of the invention.

Figure 9 displays an RNC according to the invention.

Figure 10 displays a Node B according to the invention.

Figure 11 displays a User Equipment according to the invention.

DESCRIPTION OF PREFERRED EMBODIMENTS

Figure 2 shows a preferred layered protocol structure, a protocol stack, according to the invention. The L2 MAC layer of figure 1 has been extended and divided into two sub-layers, a new L2 MAC sub-layer and a new MAC-ARQ sub-layer. Essentially the new L2 MAC sub-layer corresponds to the prior art L2 MAC sub-layer of figure 1. The MAC-ARQ plus the MAC layer could be regarded as one single MAC layer extended to also include hybrid ARQ functionality. However, for reasons of explanation they are preferably regarded as separate sub-layers. Further, on the network side, considering them as separate protocol sub-layers physically better corresponds to the physical entities where they reside. As illustrated in figure 2 on the UTRAN-side (or network side) L2 MAC sub-layer is preferably located in RNC, whereas L2 MAC-ARQ sub-layer is located in Node B. Hybrid ARQ protocol combine successively received retransmissions. It is a great advantage to have the hy-

brid ARQ protocol close to the physical layer and, particularly, in Node B. Among the advantages achieved thereby, e.g., the roundtrip delay is reduced as compared to a location in RNC. Within this patent application the protocol
5 layers, except for L2 MAC and L2 MAC-ARQ as just explained, correspond to those of figure 1.

With reference to figure 3, Node B 1 and Node B 2 of a radio communications system are logical nodes responsible for radio transmission/reception in one or more cells to/from
10 the User Equipment UE. BS 1 and BS 2 are physical entities representing Node B 1 and Node B 2 respectively. Node B 1 and Node B 2 terminate the air interface, called Uu interface within UMTS, between UE and respective Node B towards the radio network controller RNC. In UMTS the interface
15 between a Node B and an RNC is called Iub interface.

Preferably, all Nodes B of the radio communications system operate according to the invention for outstanding performance. However, the invention can also be used in systems also including Nodes B not operating according to the in-
20 vention.

Figure 4 describes somewhat more detailed than figure 2 the information transfer between the sub-layers of the protocol stack. In an exemplary situation, and with reference to figure 3, UE communicates over a radio link associated with
25 BS 1. Packet switched data is transmitted in protocol data units, PDUs, in both directions. Each PDU is transported on a transport channel in at least one transport block, TB, as shown in figure 4. Preferably there is one TB for each PDU. As described above, transmission errors on the transport channel are corrected and detected by layer L1. Each
30 transport block, TB, in figure 4 can be provided an individual CRC error-detecting checksum prior to transmission

on the physical channel. However, preferably a transmission unit, carrying one or more TBs, is provided only one CRC error-detecting checksum. If a transmission unit is detected to be in error on the receiving side, this is reported to the L2 MAC layer.

L2 MAC layer can request retransmission of transmission units received in error. Transmission units, detected to be in error, still carry information that should not be wasted. Preferably hybrid ARQ, utilizing information available from earlier transmission(s) of a transmission unit by proper combining with the latest retransmission, is used prior to an L2 MAC layer request for retransmission.

It is preferred that the Hybrid ARQ is terminated in Node B. Given L2 RLC located in RNC, the RLC layer should not be responsible of Hybrid ARQ. According to preferred embodiments of the invention, an L2 MAC-ARQ sub-layer is responsible of Hybrid ARQ. At UTRAN-side the L2 MAC-ARQ sub-layer is located in Node B.

One reason for terminating the Hybrid ARQ in Node B is the reduction of roundtrip delay as compared to terminating it in RNC. Another reason is that Node B is capable of using soft combining of multiply transmitted data packets, whereas RNC generally only receives hard-quantized bits.

At the receiving end, error detection is also performed by layer L2 RLC of figure 4. If an RLC protocol data unit, PDU, is received in error or the PDU is missing, it will be requested for retransmission at a point in time when a status report is established by the RLC layer. RLC PDUs are transferred to/from the MAC layer SDUs. The MAC SDU (Service Data Unit) possibly includes a header not included in the RLC PDU. As explained in relation to figure 2, according to the invention there are preferably two UTRAN MAC

sub-layers, an L2 MAC sub-layer and an L2 MAC-ARQ sub-layer. In a preferred embodiment of the invention, the L2 MAC sub-layer is located in RNC and the L2 MAC-ARQ sub-layer is located in Node B. As previously described, the
5 RLC PDUs are transferred in transport blocks, TBs, on the physical channel. In the uplink direction the L2 MAC-ARQ layer transfers TBs, possibly after combining of multiple (re-)transmissions of the respective TBs, indicated to be error-free to the L2 MAC layer.

10 A network layer PDU or L3 PDU can comprise several RLC PDUs, as illustrated in figure 4. RLC PDUs are reassembled into RLC service data units, RLC SDU, prior to delivery to higher layer PDU. The L3 protocol can be, e.g., the Internet Protocol, IP. Upon reception from L3, RLC SDUs are
15 segmented into RLC PDUs.

Figure 5 gives an overview of the uplink protocol structure according to the preferred embodiment of the invention. «RNC», «Node B 1», «Node B 2» and «UE» have been described in relation to figure 3. «MAC-ARQ 1» and «MAC-ARQ 2» are
20 MAC-ARQ protocol layers according to the invention of Nodes B «Node B 1» and «Node B 2» respectively. In User Equipment «UE», an integer number of RLC PDUs «1», «2», ..., «i» are segmented into a MAC-layer PDU «MAC PDU» adapted for uplink transmission in one transmission time
25 interval, TTI. Preferably, uplink transmissions are performed on an enhanced uplink channel with transmission time intervals shorter than transmission time intervals of prior art. Each Node B «Node B 1», «Node B 2» (positively) acknowledges «ARQ Status» successfully received MAC PDUs.
30 Optionally, it may negatively acknowledge «ARQ Status» unsuccessfully received MAC PDUs. The acknowledgements are transmitted in downlink direction to User Equipment «UE». With only positive acknowledgements, if no acknowledgement

is received within a predetermined time, «UE» retransmits the unacknowledged MAC PDU, otherwise «UE» cancels the MAC PDU from buffer storing not yet acknowledged MAC PDUs. With optional negative acknowledgements the predetermined
5 time period becomes less critical. However, due to the risk of misinterpreting a negative acknowledgement as a positive acknowledgment, channel dependent probability of such misinterpretation needs to be considered for various channel environments for an optimum selection.

10 MAC PDUs received by respective MAC-ARQ protocol layer «MAC-ARQ 1», «MAC-ARQ 2» of Nodes B «Node B 1», «Node B 2» are delivered to Radio Network Controller «RNC», which reorders received MAC PDUs into sequential order. This is needed as, e.g., a single Node B may obtain successfully
15 transmitted and received MAC PDUs out of order due to varying number of required retransmissions of different PDUs. Another exemplary reason is that at handover involving a plurality of Nodes B, different MAC PDUs of an RLC PDU are received and (re-)transmitted to RNC at different Nodes B
20 for assembly in RNC, whereas for downlink transmissions there is only one transmitting entity (Node B) and one receiving entity (UE).

A reordering entity in radio network controller «RNC» provides in-sequence delivery of RLC PDUs «RLC PDUs», received
25 in RNC, to RLC layer «RLC». Two alternative number sequences for reordering are considered:

- reordering based on RLC sequence numbers for both UM and AM RLC; or
- special sequence numbers on MAC level.

30 Special sequence numbers on MAC level is used for downlink HS-DSCH. However, if reordering is made in RNC number of

sequences can be reduced if reordering is based on RLC sequence numbers, keeping transmission overhead at a minimum.

The risk of receiving duplicate RLC PDUs also needs consideration. Elimination of duplicate RLC PDUs can be based on
5 RLC sequence numbers as well. The elimination of duplicate RLC PDUs also reduces the negative impact of positive acknowledgements being received as negative acknowledgments in UE, if negative acknowledgments are made use of.

Preferably, hybrid ARQ is used, softly combining, if more
10 than one, successive received (re-)transmissions of each MAC PDU. An identification of process identity «ProcessID» and an indicator of new data «NewData» in addition to payload «Payload» may either be included in data packets «MAC PDU» according to the HARQ protocol as indicated in figure
15 6 or be handled separately but in association with payload data, illustrated in figure 7. The payload field «Payload» comprises an integer number of RLC PDUs. The indicator of new data «NewData» indicates whether or not a MAC PDU is a retransmission and is included for control of soft combining.
20 ing. This may be explicitly indicated, or indicated implicitly by a sequence number, which is increased for each transmission of a not earlier transmitted MAC PDU.

There is need for greater reliability at transmission of process identity and new data indicator fields «ProcessID»,
25 «NewData», than payload. If control data is not received, corresponding payload cannot be soft-decision combined with data of other transmissions. Therefore, control fields «ProcessID» and «NewData» are transferred with higher reliability than the data channel transferring the payload.
30 The higher reliability can be achieved by, e.g., more error resistant error control coding or increased transmission power. Preferably, control fields for process identity

«ProcessID» and new data indicator «NewData» are transmitted on a control channel separate from the data channel. The control and data channels are synchronized.

In addition to the control fields mentioned above there are
5 control fields of nature well known in the art carrying information on, e.g., number of payload RLC PDUs and transport block size.

A well-known (one-channel) stop-and-wait ARQ protocol does not provide sufficient throughput for most studied relevant
10 cases. According to the invention selective repeat or N-channel stop-and-wait ARQ is preferred.

For N-channel stop-and-wait, Node B needs to store soft samples of up to N different MAC PDUs for each UE. The N channels are time multiplexed as illustrated in figure 8.
15 For a particular channel, no further data is transmitted until an acknowledgement is received or time for acknowledgement has elapsed according to a stop-and-wait protocol. I.e. acknowledgements are scheduled such that acknowledgement «1st ACK» acknowledging data transmitted in a 1st
20 channel «1st channel» arrives not later than next transmission instant of 1st channel «1st channel». The same holds for 2nd channel «2nd channel» up to Nth channel «Nth channel»

Figure 9 displays an RNC according to the invention. Receive means 1 receives first protocol data units, e.g. MAC
25 PDUs, transferred from one or more Nodes B. Received first protocol data units are stored by buffering means 2. The first protocol data units are segmented into second protocol data units, e.g. RLC PDUs, by segmentation means 3. Reorder means 4 operates on the segmented buffered data
30 units and reorders the second protocol data units as need be in consecutive order according to a sequence number. For transfer to higher layers, reassemble means 5 reassem-

bles the second protocol data units into service data units, which are transferred by transfer means 6.

The radio network further comprises processing means 7, verifying second protocol data units according to an error
5 detecting code. Acknowledgments, preferably included in status reports, of second protocol data units are transmitted by transmit means 8.

Figure 10 displays a Node B according to the invention. Node B transmits responses to UE providing information on
10 the outcome of data transfers over the radio interface from UE to Node B. In an example situation receive means 9 receive one or more first protocol data units, e.g. MAC PDUs, the received first protocol data units are stored in buffering means 10 and processed in protocol entity 11
15 determining, among other things, whether the received data unit is valid codeword. Transmit means 12 accordingly acknowledges the received data unit to the sender (UE). When a multitude of transmissions are required for obtaining a valid received protocol data unit, the number
20 of (re-)transmissions may be reduced by properly combining the transmissions. Optional combining means 13, performs such combining, preferably using soft decision information from the receive means 9.

Figure 11 displays a User Equipment, UE, according to the
25 invention. Assemble means 14 assembles second protocol data units, e.g. RLC PDUs, to first protocol data units, e.g. MAC PDUs. The first protocol data units are buffered by buffering means 15 and transmitted one or more times, as need be, by transmit means 16. If transmission is consid-
30 ered successful according to, appeared or non-appeared, acknowledgements, positive or negative acknowledgements of first protocol data units are received by receive means 17.

Positive or negative acknowledgments of second protocol data units are received by receive means 18 optionally distinguishing from receive means 17.

A person skilled in the art readily understands that the receiver and transmitter properties of a BS or a UE are general in nature. The use of concepts such as BS, UE or RNC within this patent application is not intended to limit the invention only to devices associated with these acronyms. It concerns all devices operating correspondingly, or being obvious to adapt thereto by a person skilled in the art, in relation to the invention. As an explicit non-exclusive example the invention relates to mobile stations without a subscriber identity module, SIM, as well as user equipment including one or more SIMs. Further, protocols and layers are referred to in close relation with UMTS terminology. However, this does not exclude applicability of the invention in other systems with other protocols and layers of similar functionality.

The invention is not intended to be limited only to the embodiments described in detail above. Changes and modifications may be made without departing from the invention. It covers all modifications within the scope of the following claims.

CLAIMS

1. A method of reducing impact of transmission errors by means of a retransmission protocol, the method c h a r - a c t e r i z e d i n that a retransmission loop involving packet radio transmissions from user equipment to a control element connected to one or more radio base stations, the user equipment radio transmissions being received at one or more radio base stations for forwarding to the control element, the base station acknowledging, positively or negatively, transmissions from the user equipment and the control element acknowledging, positively or negatively, transmissions forwarded to it.

2. The method according to claim 1 c h a r a c t e r - i z e d i n that for a process of retransmission, if same transmitted packet information content is received more than once, the received transmissions are combined.

3. The method according to claim 2 c h a r a c t e r - i z e d i n that successive received packet transmissions of the same information content are combined in the base station prior to determining whether or not the radio base station should acknowledge the transmitted information content.

4. The method according to claim 2 or 3 c h a r a c - t e r i z e d i n that whether or not the packet information content is the same is determined by means of a new data indicator.

5. The method according to claim 4 c h a r a c t e r - i z e d i n that the new data indicator, accompanying packet information, is transmitted on a reliable control channel.

6. The method according to any of claims 2-5 c h a r -
a c t e r i z e d i n that the process is identified by
means of a process identity.

7. The method according to claim 6 c h a r a c t e r -
5 i z e d i n that the process identity, accompanying
packet information, is transmitted on a reliable control
channel.

8. The method according to any of claims 1-7 c h a r -
a c t e r i z e d i n that the control element reorders
10 received packets.

9. The method according to claim 8 c h a r a c t e r -
i z e d i n that the received packets are reordered into
sequential order.

10. The method according to claim 9 c h a r a c t e r -
15 i z e d i n that the sequential order is determined from
RLC sequence number.

11. The method according to claim 9 c h a r a c t e r -
i z e d i n that the sequential order is determined from
MAC sequence number.

20 12. The method according to any of claims 1-11 c h a r -
a c t e r i z e d i n that the method reduces delay of
uplink transmissions, the delay being associated with the
retransmissions.

13. A signal format for uplink transmissions from user
25 equipment to radio base station of a radio communications
system, the signal format c h a r a c t e r i z e d b y
signal elements

- process identity,
- new data indicator, and

- payload,

the new data indicator indicating whether or not payload data of a process with identity as indicated by the process identity element has been transmitted previously.

5 14. The signal format according to claim 13 c h a r a c -
t e r i z e d i n that the process identity and new data
indicator elements are more strongly protected by a forward
error control code than payload.

10 15. The signal format according to claim 13 or 14
c h a r a c t e r i z e d i n that the process identity
and new data indicator elements are transmitted on a con-
trol channel in synchronism with transmissions of the pay-
load element.

15 16. The signal format according to claim 15 c h a r a c -
t e r i z e d i n that the control channel is a shared
control channel of a UMTS or WCDMA system.

17. The signal format according to claim 15 c h a r a c -
t e r i z e d i n that the control channel is a dedicated
control channel of a UMTS or WCDMA system.

20 18. The signal format according to any of claims 13-17
c h a r a c t e r i z e d b y the payload element com-
prising an integer number of radio link control protocol
data units (RLC PDUs).

25 19. The signal format according to any of claims 13-18
c h a r a c t e r i z e d i n that the process identity,
new data indicator and payload elements are arranged for
uplink transmission in a transmission time interval shorter
than 10 milliseconds.

20. The signal format according to claim 19 c h a r a c -
t e r i z e d i n that the process identity, new data in-
dicator and payload elements are arranged for uplink trans-
mission in a transmission time interval shorter than 4 mil-
5 liseconds, e.g. 2 ms.

21. A radio network controller of a radio communications
system c h a r a c t e r i z e d b y

- receive means, for receiving first protocol
data units,
- 10 - buffering means, for buffering received first
protocol data units,
- segmentation means, for segmenting received
first protocol data units into second protocol
data units
- 15 - reassemble means, for reassembling second pro-
tocol data units into service data units.
- transfer means, for transferring service data
units.

22. The radio network controller according to claim 21
20 c h a r a c t e r i z e d b y

- reordering means, for reordering second proto-
col data units,

23. The radio network controller according to claim 21
c h a r a c t e r i z e d b y

- 25 - reordering means, for reordering first protocol
data units,

24. The radio network controller according to any of
claims 21-23 c h a r a c t e r i z e d b y

- transmit means,

the processing means being arranged to verify second protocol data units according to an error detecting code and the transmit means transmitting positive or negative acknowledgments depending on whether or not the second protocol data unit is detected to be erroneous.

25. The radio network controller according to claim 21 or 24 characterized in that the reordering means rearranges the second protocol data units according to an RLC sequence number.

26. The radio network controller according to any of claims 21-25 characterized by receive means arranged for receiving first protocol data units concerning a particular connection from a plurality of first protocol data senders.

27. The radio network controller according to any of claims 21-26 characterized in that the first protocol data units are MAC PDUs.

28. The radio network controller according to any of claims 21-27 characterized in that the second protocol data units are RLC PDUs.

29. The radio network controller according to any of claims 21-28 characterized in that the radio network controller is a radio network controller of a UMTS or WCDMA system.

30. A radio base station characterized by

- receive means, for receiving one or more first protocol data units,

- a protocol entity, for processing first protocol data units, and
- transmit means, for transmitting acknowledgments and for forwarding of first protocol data units.

5

31. The radio base station according to claim 30 characterized by

- buffering means, for buffering one or more first protocol data units.

10 32. The radio base station according to claim 30 or 31 characterized by the protocol entity being arranged for verifying one or more first protocol data units according to a forward error control code, and depending on the outcome positively or negatively acknowledging to an uplink transmitting entity received first one or
15 more protocol data units.

33. The radio base station according to any of claims 30-32 characterized by means for combining received first protocol data units, the protocol entity being
20 arranged to verify the combined protocol data unit according to a forward error control code and depending on the outcome positively or negatively acknowledging to an uplink transmitting entity the latest received protocol data unit of the combination.

25 34. The radio base station according to claim 33 characterized in that the first protocol data units with same process identity are combined according to a received new data indicator.

35. The radio base station according to any of claims 30-34 characterized in that the first protocol data units are MAC PDUs.

36. The radio base station according to any of claims 30-35 characterized in that the radio base station is a radio base station of a UMTS or WCDMA system.

37. A user equipment apparatus of a radio communications system characterized by

- 10 - assemble means for assembling one or more second protocol data units into one or more first protocol data units,
- buffering means for buffering first protocol data units,
- 15 - transmit means for transmitting first protocol data units,
- receive means for receiving one or more acknowledgments of first protocol data units, and
- receive means for receiving one or more acknowledgments of second protocol data units.

20 38. The user equipment apparatus characterized by the transmit means being arranged to retransmit one or more first protocol data units if negatively acknowledged or not positively acknowledged within a predetermined time.

25 39. The user equipment apparatus according to claim 37 or 38 characterized by buffering means being arranged to release buffer space of one or more first protocol data units if positively acknowledged or not negatively acknowledged within a predetermined time.

40. The user equipment apparatus according to any of claims 37-39 characterized by transmit means being arranged to transmit first protocol data units in transmission time intervals shorter than 10 milliseconds.

41. The user equipment apparatus according to claim 40 characterized by transmit means being arranged to transmit first protocol data units in transmission time intervals shorter than 4 milliseconds, e.g. 2 milliseconds.

42. The user equipment according to any of claims 37-41 characterized in that the first protocol data units are MAC PDUs.

43. The user equipment according to any of claims 37-41 characterized in that the second protocol data units are RLC PDUs.

44. The user equipment apparatus according to claims 37-43 characterized in that the user equipment apparatus is user equipment of a UMTS or WCDMA system.

45. Radio communications system characterized by means for carrying out the method in any of claims 1-12.

46. A radio communications system characterized by a plurality of radio network controllers according to any of claims 21-29.

47. A radio communications system characterized by a plurality of radio base stations according to any of claims 30-36.

48. A radio communications system characterized by a plurality of user equipment apparatuses according to any of claims 37-44.

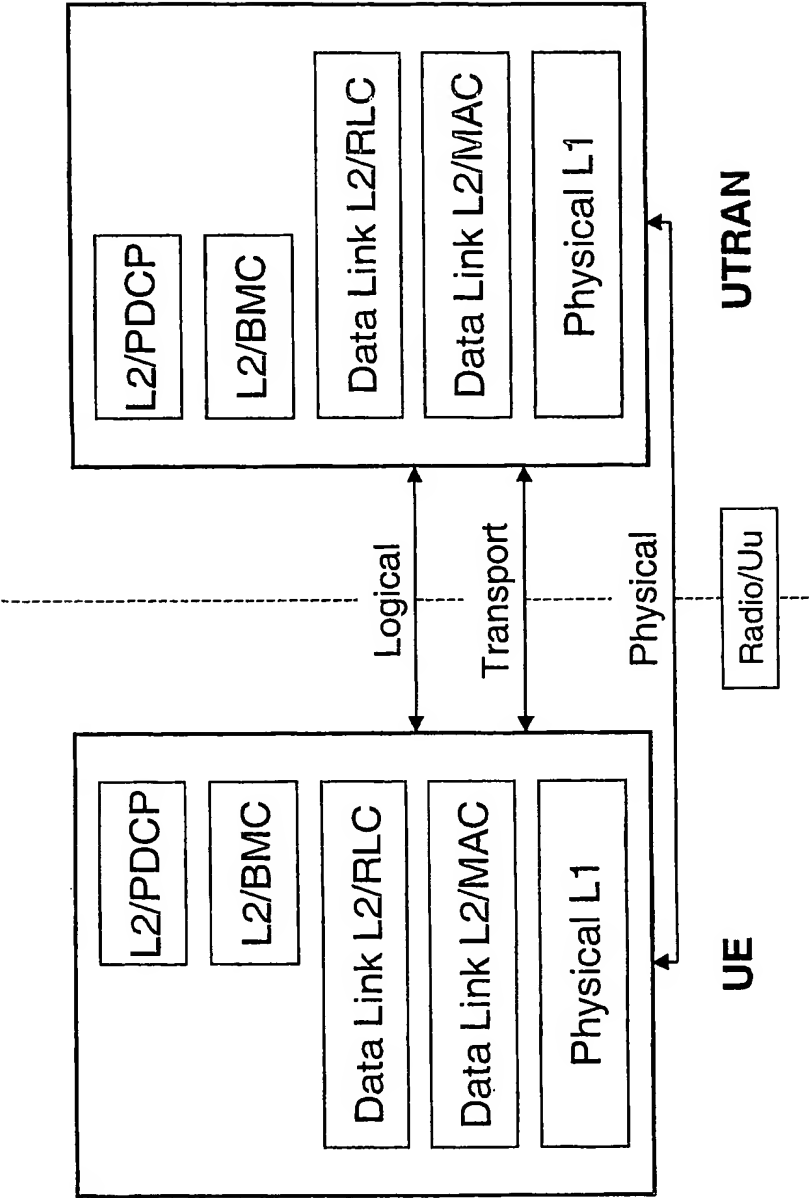


Fig. 1

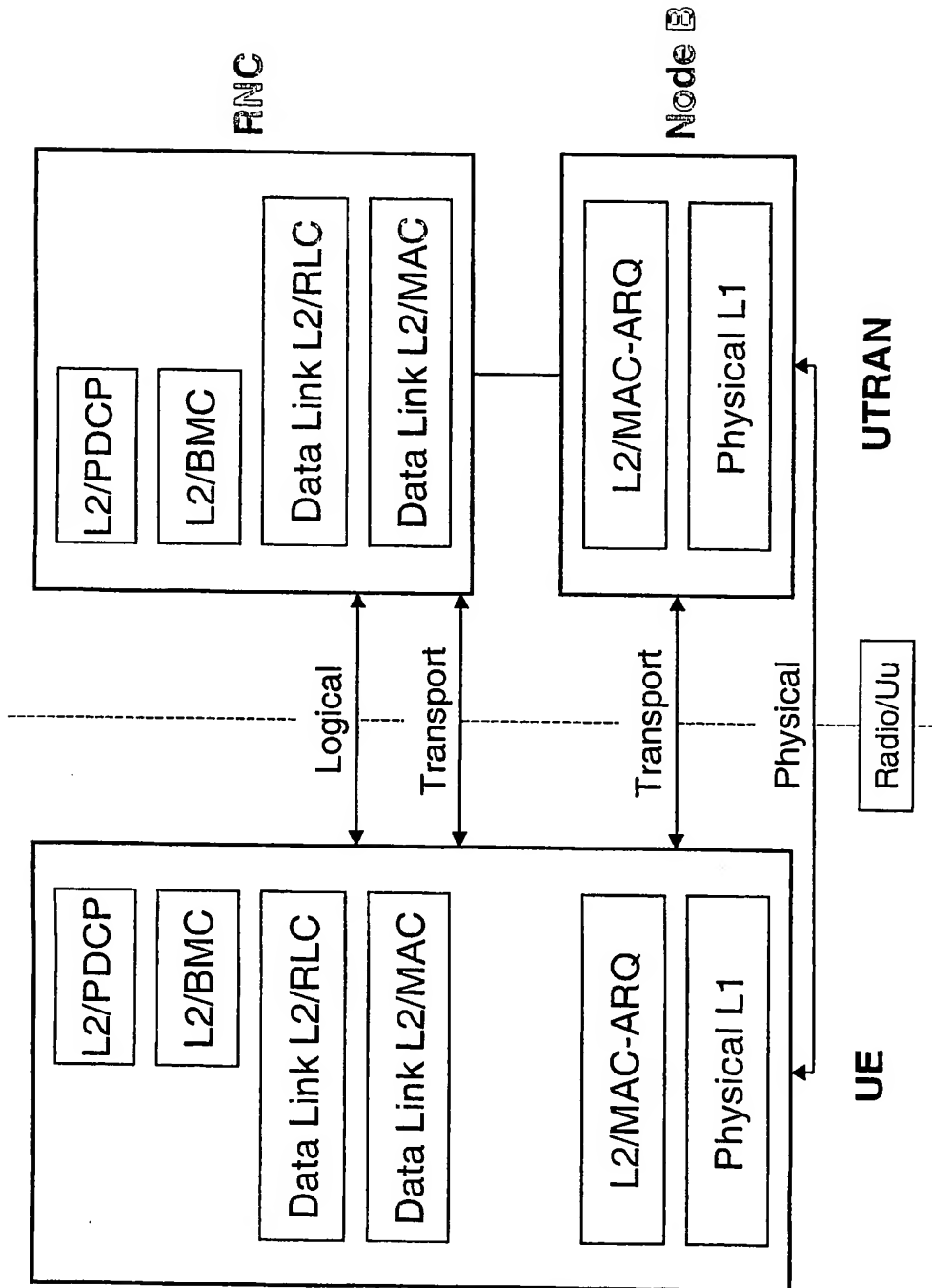
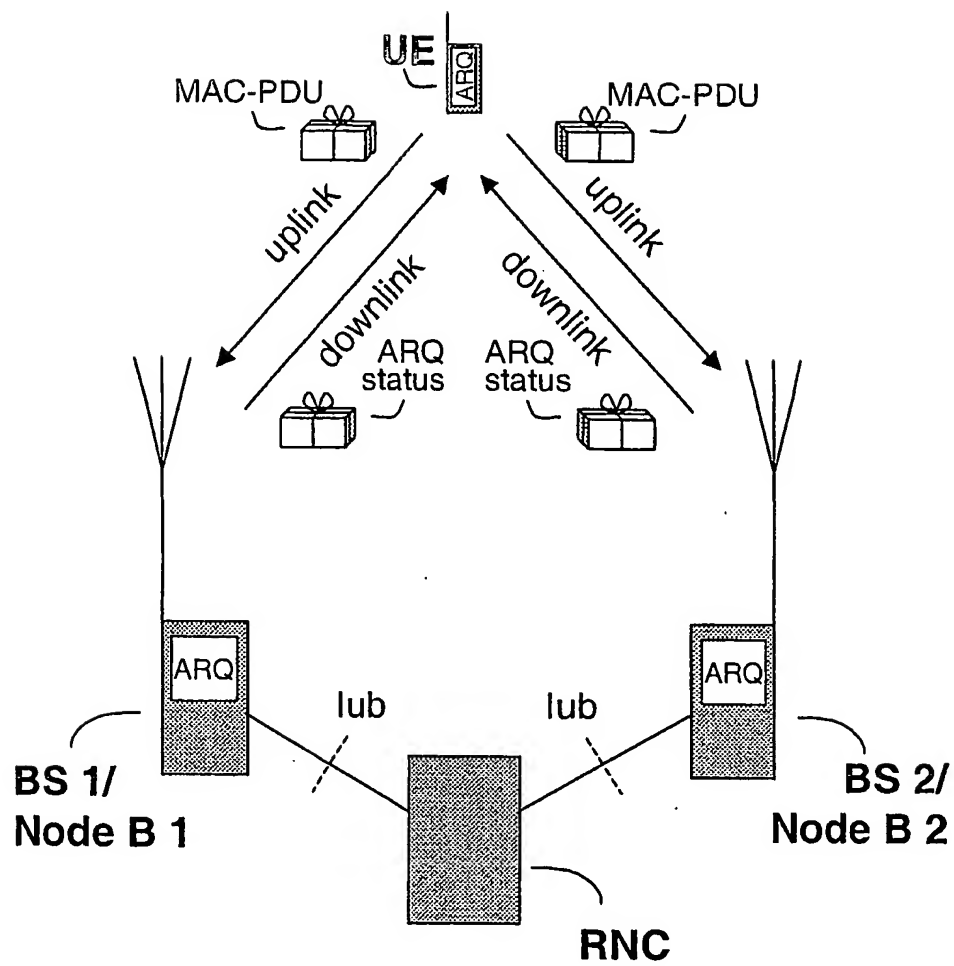
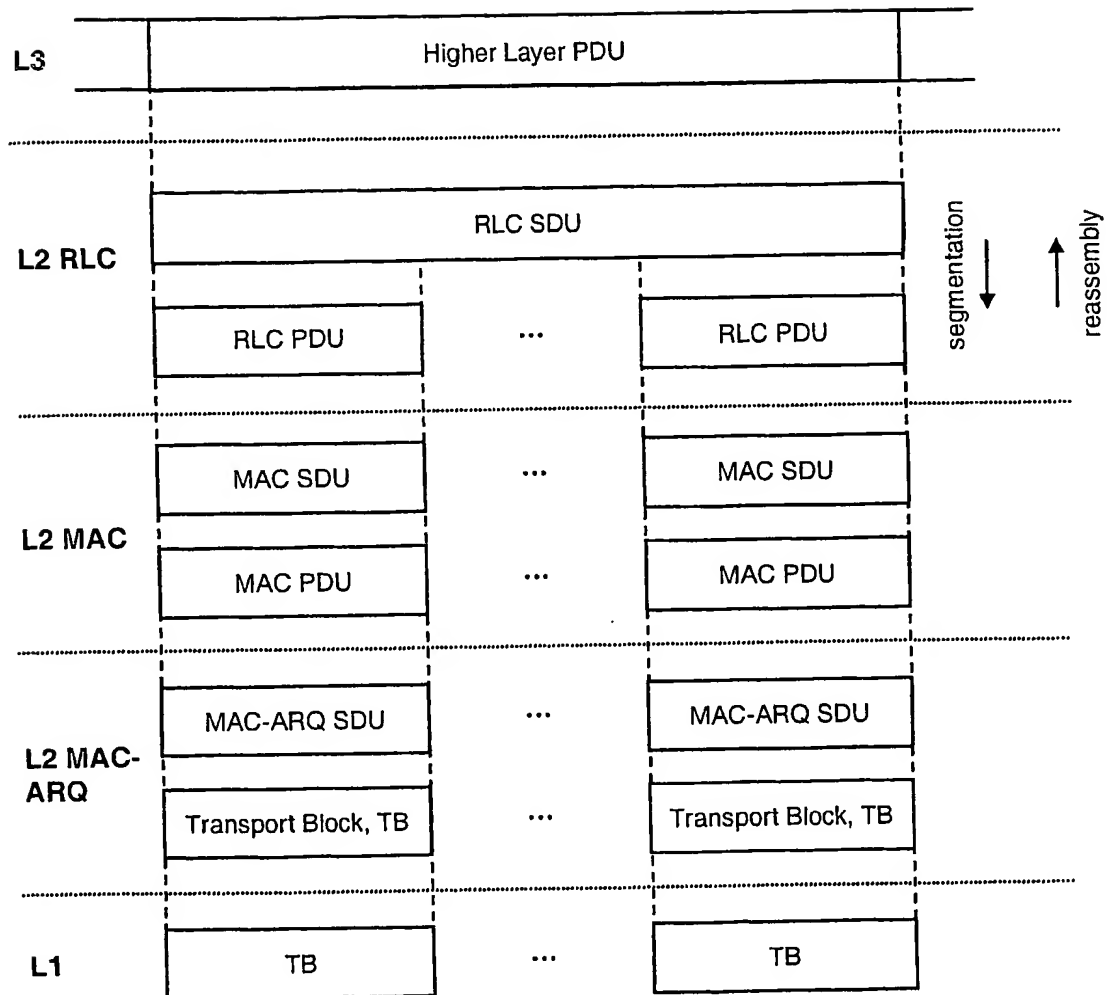


Fig. 2

**Fig. 3**

**Fig. 4**

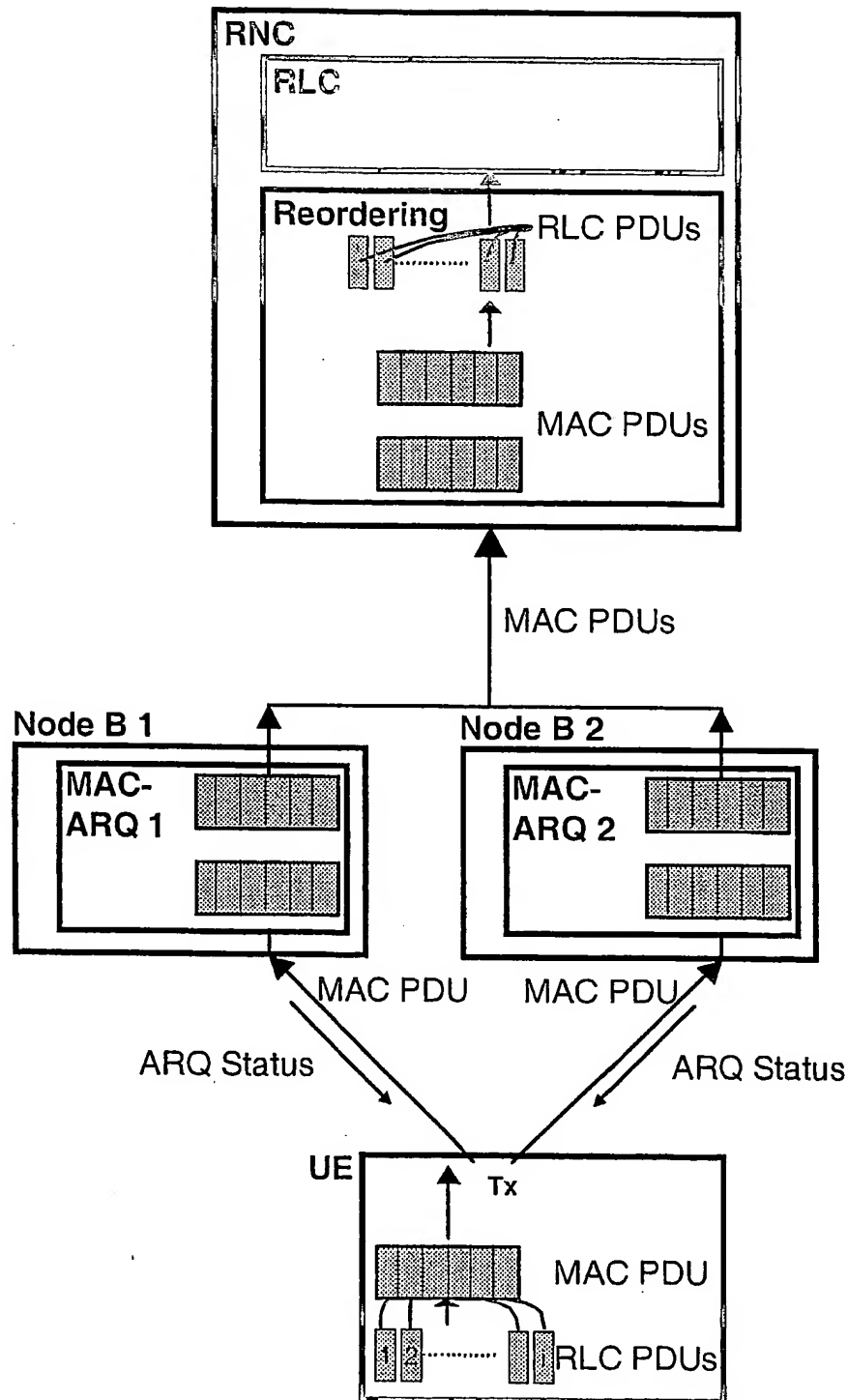




Fig. 6

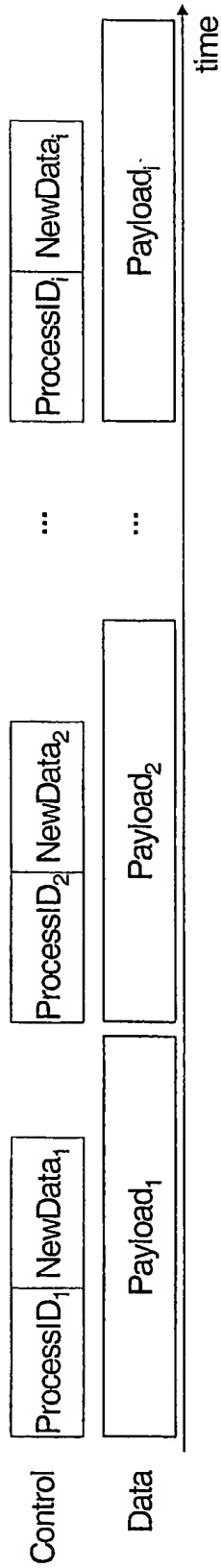


Fig. 7

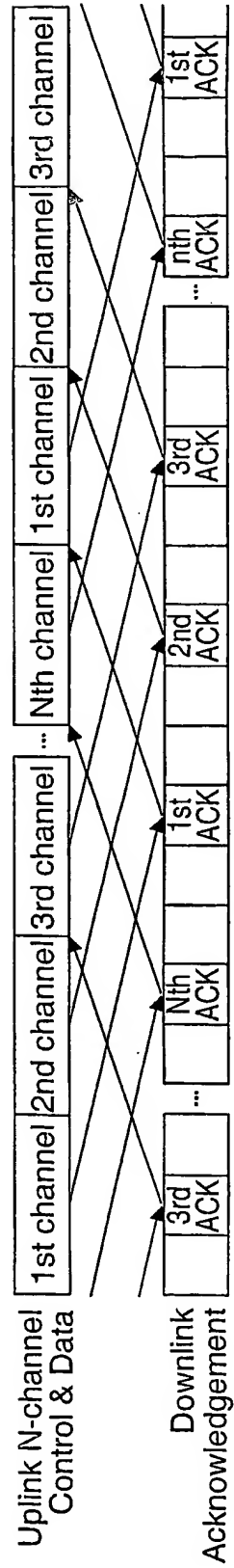


Fig. 8

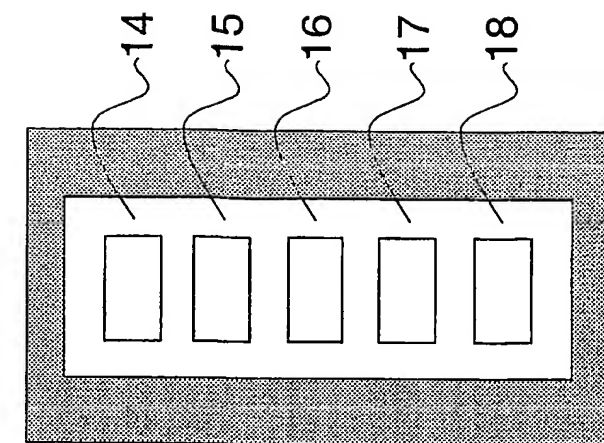


Fig. 11

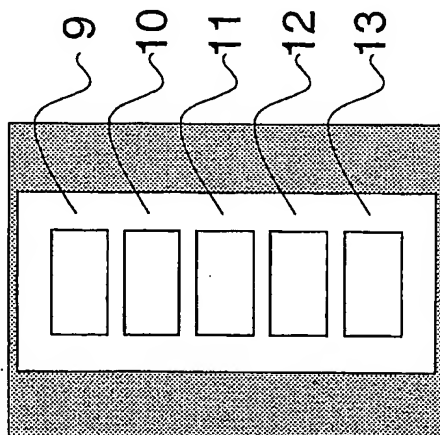


Fig. 10

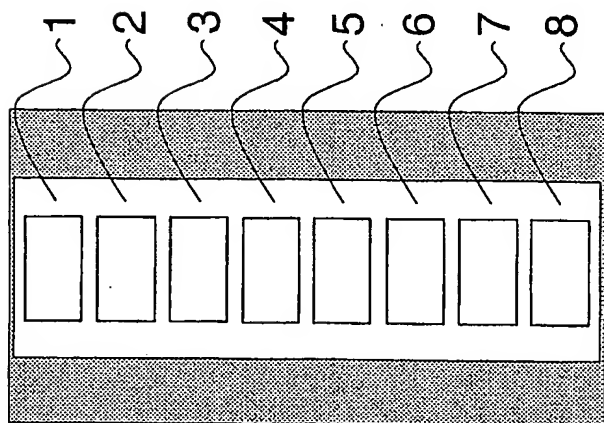


Fig. 9

INTERNATIONAL SEARCH REPORT

International application No.

PCT/SE 2003/000589

A. CLASSIFICATION OF SUBJECT MATTER

IPC7: H04L 1/18

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC7: H04Q, H04B, H04L

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

SE,DK,FI,NO classes as above

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

EPO-INTERNAL, WPI DATA, PAJ, INSPEC, XPI3E

C. DOCUMENTS CONSIDERED TO BE RELEVANT

| Category* | Citation of document, with indication, where appropriate, of the relevant passages | Relevant to claim No. |
|-----------|---|-----------------------|
| X | US 2003007480 A1 (SEONG-HUN KIM ET AL), 9 January 2003 (09.01.2003), see sections [001]-[0033] -- | 1-12, 21-48 |
| X | WO 019376 03 (INTERDIGITAL TECHNOLOGY CORPORATION), 6 March 2003 (06.03.2003), see sections [0002]-[0005] and [0022]-[0027] -- | 1-12, 30-45, 47-48 |

☒ Further documents are listed in the continuation of Box C.☒ See patent family annex.

* Special categories of cited documents:

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier application or patent but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance: the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance: the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search

26 January 2004

Date of mailing of the international search report

30 -01- 2004

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INTERNATIONAL SEARCH REPORT

International application No.

PCT/SE 2003/000589

| C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT | | |
|---|--|----------------------------|
| Category* | Citation of document, with indication, where appropriate, of the relevant passages | Relevant to claim No. |
| X | 3GPP TS 25.308 v5.3.0 (2002-12) 3rd Generation Partnership Project; Technical Specification Group Radio Access Network; High Speed Downlink Packet Access (HSDPA); Overall description; Stage 2 see the whole document and especially page 18 chapter 7.1.2.1 | 13-20 |
| A | -- | 1-12,21-48 |
| A | WO 02065797 A1 (TELEFONAKTIEBOLAGET LM ERICSSON (PUBL)), 22 August 2002 (22.08.2002), page 5, line 6 - page 6, line 11 | 1-12,21-48 |
| A | Haitao Lin et al "TPC performance analysis of CDMA systems with RLP and MAC layer retransmissions" Modeling, Analysis and Simulation of Computer and Telecommunications Systems, 2002. MASCOTS 2002. Proceedings. 10th IEEE International Symposium on Page(s): 313-320 ISSN: 1526-7539 INSPEC Accession Number: 7603849 see abstract, section 2 and 2.1 and figure 1 | 1-12,30-36, 38-45,47-48 |
| A | Chatterjee, M. et al "MAC layer retransmissions in 1XTREME", Personal, Indoor and Mobile Radio Communications, 2002. The 13th IEEE International Symposium on 15-18 Sept. 2002 Page(s): 1452-1456 vol. 3 INSPEC Accession Number: 7678121 see abstract and figure 2 | 1-12,30-36, 38-45,47-48 |

INTERNATIONAL SEARCH REPORT

International application No.
PCT/SE 2003/000589

Box No. II Observations where certain claims were found unsearchable (Continuation of item 2 of first sheet)

This international search report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☐ Claims Nos.:
because they relate to subject matter not required to be searched by this Authority, namely:

2. ☐ Claims Nos.:
because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:

3. ☐ Claims Nos.:
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

Box No. III Observations where unity of invention is lacking (Continuation of item 3 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

see next page

1. ☒ As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims.
2. ☐ As all searchable claims could be searched without effort justifying an additional fee, this Authority did not invite payment of any additional fee.
3. ☐ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:

4. ☐ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

Remark on Protest

- ☒ The additional search fees were accompanied by the applicant's protest.
☐ No protest accompanied the payment of additional search fees.

INTERNATIONAL SEARCH REPORT

International application No.
PCT/SE 2003/000589

I) Claims 1-12, 30-45, 47-48 relating to a method, a radio base station, and an user equipment characterised by sending or receiving acknowledgements.

II) Claims 13-20 relating to a signal format for uplink transmission/retransmission.

III) Claims 21-29 and 46 relating to a radio network controller arranged to: receive and buffer a first PDU; segment a first PDU into a second PDU; reassemble second PDU into SDU; transfer SDU.

INTERNATIONAL SEARCH REPORT
Information on patent family members

24/12/2003

International application No.
PCT/SE 2003/000589

| | | | | | | | |
|-------|------------|----|------------|------|------------|---|------------|
| US | 2003007480 | A1 | 09/01/2003 | KR | 2002095125 | A | 20/12/2002 |
| ----- | | | | | | | |
| WO | 019376 | 03 | 06/03/2003 | NONE | | | |
| ----- | | | | | | | |
| WO | 02065797 | A1 | 22/08/2002 | AU | 3961301 | A | 17/09/2001 |
| | | | | EP | 1358770 | A | 05/11/2003 |
| | | | | SE | 0100475 | D | 00/00/0000 |
| ----- | | | | | | | |